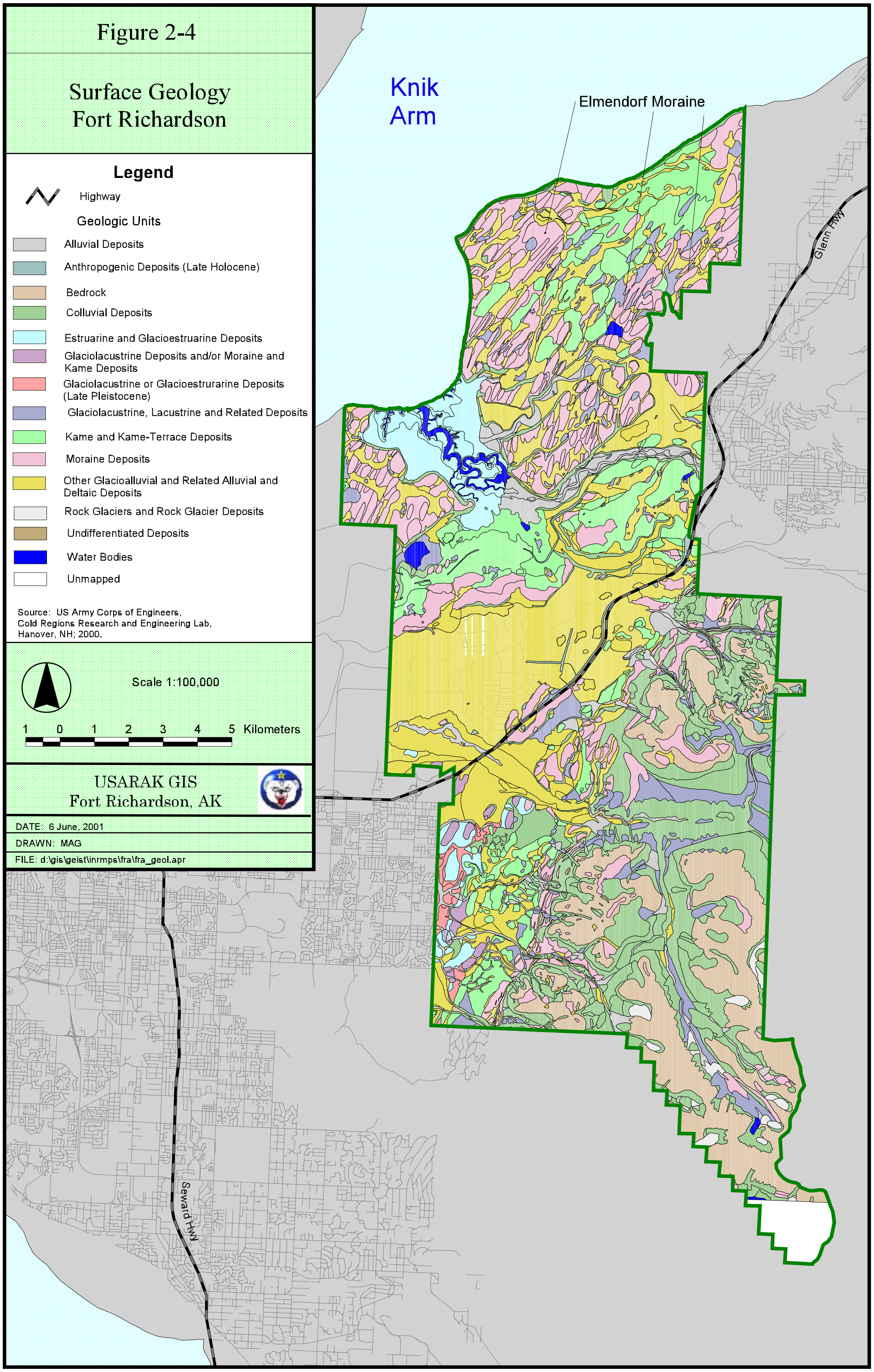
Figure 2-4. Fort Richardson Surface Geology.



Rugged slopes of the Chugach Mountains.

of the mountain range to 900 feet at Point Woronzof (CH2M Hill 1994b). The upper part of the deposits is composed of gravel and sand ranging from 30 to 100 feet thick. Underlying the gravel is Bootlegger Cove Clay, a 60 to 200 foot layer of clay and silt with interbeds of sand. Below the clay is a 100 to 200 foot layer of sand and gravel that provides the major groundwater aquifer for the area (CH2M Hill 1994b). Between the aquifer layer and the bedrock is a layer of poorly sorted glacial sediments (Gossweiler 1984).

Bootlegger Cove clay is nearly impermeable and serves as a confining layer between upper and lower gravel layers. It inhibits downward flow of pollutants from groundwater in upper layers and results in an artesian aquifer in the lower gravel layer. Water from this aquifer flows into the Knik and Turnagain Arms at an estimated rate of 75 million gallons per day (CH2M Hill 1994b).

The northern third of the Anchorage lowland consists of a complex of glacially deposited materials. These materials include morainal deposits of the Elmendorf Moraine, marking the margin of the former glacier occupying Knik Arm. Other glacial deposits consist of diamicton and other unsorted and poorly sorted till material and glacial alluvium, including glacial outwash gravel, kames, and kame terraces deposited at the edge of the former glacier (CH2M Hill 1994b).

Fort Richardson straddles both the alluvial fan of the Anchorage plain and the moraine and glacial alluvium complex near the shore of Knik Arm. The gravel alluvium of the Anchorage plain underlies the main cantonment. Well-bedded and well-sorted gravel and sands provide good foundation conditions and plentiful construction material. The confined gravel aquifer is 200 feet to 400 feet below the surface in this area of the post (Selkregg 1972). Groundwater flow in this confined aquifer is generally west to northwest (CH2M Hill 1994b).

Just north of the cantonment area is the southern edge of the Elmendorf Moraine, a long series of ridges running east-west across Fort Richardson and Elmendorf AFB, roughly parallel to Knik Arm. Elevations of the moraine rise to more than 300 feet, especially in the west. The moraine is chiefly till, including diamicton and poorly sorted gravel. North of the Elmendorf Moraine is a complex of moraine and glacial alluvium deposits in the form of irregularly shaped hills (CH2M Hill 1994b).

The complex of hills just south of ERF is part of this glacial alluvium deposit. Further north, on either side of ERF, are more moraine deposits. These deposits are more subdued in topography than the Elmendorf Moraine (CH2M Hill 1994b). Fort Richardson surface geology is shown in Figure 2-4.

2.2.2.1 Seismic Activity

Seismic activity in Alaska is greater than any other state in the Union. On Good Friday, March 27, 1964, southern Alaska experienced the strongest recorded earthquake in American history, estimated to be over 9.0 on the Richter Scale. The quake's epicenter was approximately 80 miles east of Fort Richardson in Prince William Sound. Although the Anchorage area did not experience great loss of life, damage from the quake was considerable. Fissures in the Bootlegger Cove Clay led to landslides in business and residential areas of Anchorage that caused extensive property damage. Total damage to Fort Richardson was assessed at $17 million.

The Fort Richardson area is seismically active and has experienced at least nine major earthquakes in the last 85 years. The area has also experienced tremors and ash fall from volcanic eruptions of Mount Spurr, Mount St. Augustine, and Mount Redoubt since 1954. Two faults, the Border Ranges Fault and the Bruin Bay-Castle Mountain Fault, border Anchorage. The Border Ranges Fault bisects Fort Richardson, running parallel to the base

Fourth Avenue in shambles after 1964 earthquake.

of the Chugach Mountains (Elmendorf AFB 1994). Another fault, located in the Chugach Mountains, skirts the Ski Bowl area of the post.

2.2.2.2 Petroleum and Minerals

Leasing and permitting for petroleum and mineral extraction on Fort Richardson is handled by the BLM. Prior to issuance of a permit that allows these activities, the Army must concur and sign a statement of non-objection.

There has been no interest in oil and gas exploration on Fort Richardson because no oil-bearing basins are known to underlie the post. Potentially significant mineral and organic resources on the post include coal, gravel, sand, and peat. While coal is found on the post, there have been no surveys to inventory the resource, nor is coal extraction likely to occur because there are vast known reserves north of Anchorage at Jonesville and on native-owned lands west of the village of Tyonek.

The most valuable and desirable mineral resource on Fort Richardson is gravel, used in highway, utility, and building construction projects. The Alaska Department of Transportation has repeatedly requested permission to extract gravel from Fort Richardson for construction on Glenn Highway and other nearby highway projects in Anchorage. As a result of these requests, 20 or more sites have been approved for gravel mining. Many of these sites are located along the Glenn Highway in the gravel-rich Elmendorf Moraine (see Figure 2-3).

There are other gravel quarries (e.g., Otter Lake and Artillery Road) where gravel is extracted and used for Fort Richardson construction projects. One commonly used pit is near Bryant Army Airfield. Public service utility projects (e.g., electrical transmission lines, water mains, sewer, natural gas and petroleum pipelines) that pass through Fort Richardson use gravel obtained from the post.

Small sources of sand can be found on the post. Two areas have been developed for extraction, one in the Ammo Storage area and another adjacent to McVeigh Marsh. Both have been closed due to impacts in sensitive areas. Peat is found in wetlands on the post, and it has been extracted from several areas for use in landscaping applications.

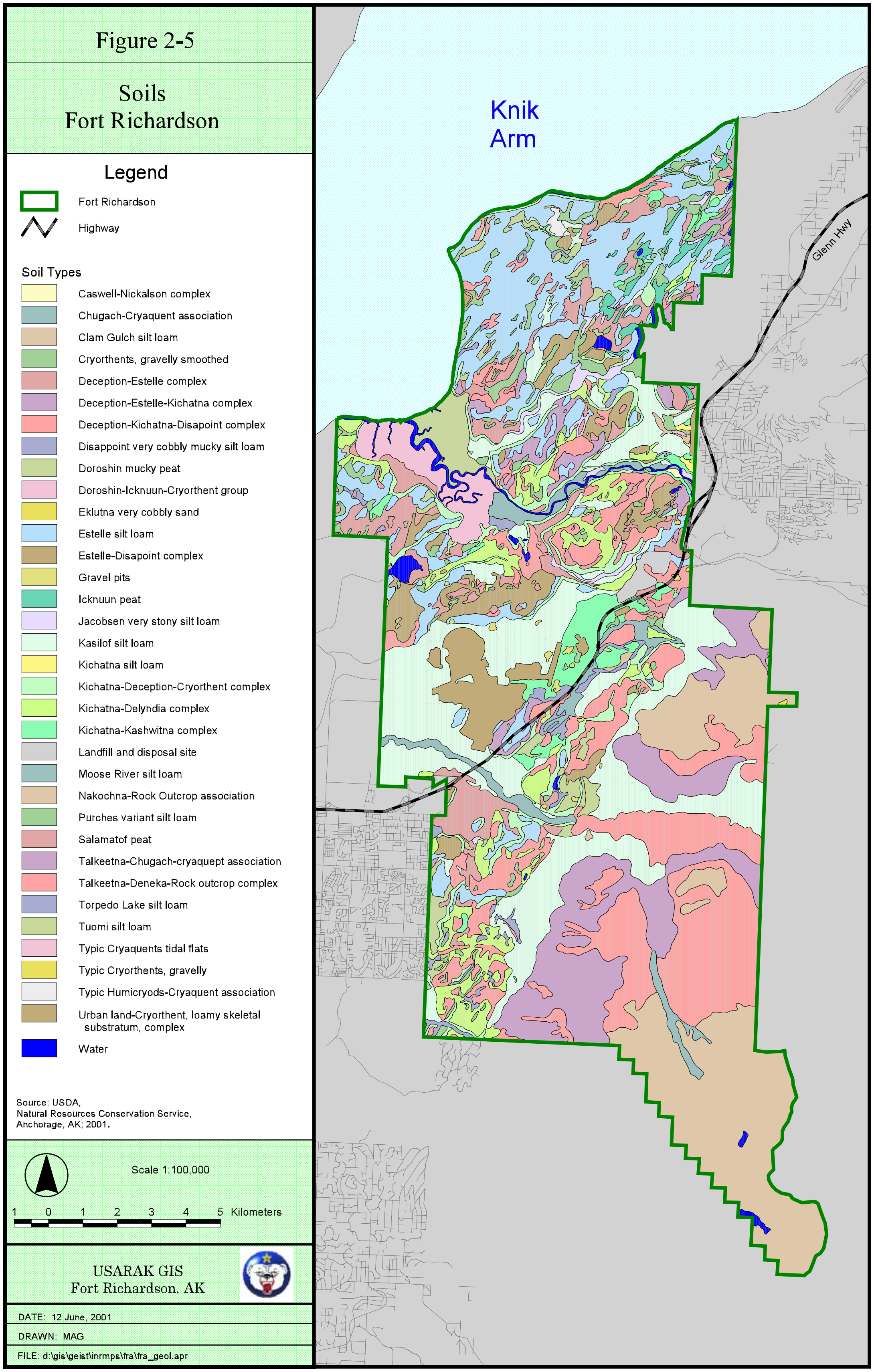
2.2.3 Soils

2.2.3.1 General

The relationship between vegetation and soil formation is inseparable. The history of soil development in the Fort Richardson area began when the Cordilleran Ice Sheet covered south-central Alaska during the Wisconsin Glaciation, 10,000 to 15,000 years ago. Climates began to warm and ice sheets melted in the late Wisconsin Glacial Period due to changes in the earth's orbit around the sun. Sediment cores from lakes on the Kenai Peninsula lowlands show that plant life returned to this area about 14,500 years ago (Elias 1995). The earliest vegetation to become established was herbaceous tundra dominated by sedges, grasses, sage, and plants in the composite family. By 13,700 years ago, the herbaceous tundra gave way to shrub tundra dominated by dwarf birch and heath plants. Deciduous forest became established by 10,300 years ago. Dwarf birch gave way to a mixture of cottonwood, balsam popular, aspen, and willow. Conifer trees appeared in the Kenai lowlands about 8,000 years ago. These first conifers were thought to be white and black spruce. Although no pollen records have been collected and analyzed in the Anchorage area, including Fort Richardson, the development and progression of the vegetative communities after the ice sheets melted are thought to closely follow the patterns found on the Kenai. Recent glacial studies indicate that the ice sheets on Fort Richardson melted about 1,000 to 1,200 years after the ones on the Kenai (Hunter et al. 1997).

Soil development is determined by five primary factors: parent material, vegetation, topography,

Figure 2-5. Fort Richardson Soils.



climate and time. Vegetation is a dominant factor of soil development, and vegetative succession at Fort Richardson is thought to follow closely with the records obtained from Hidden Lake on the Kenai Peninsula with a time delay of about 1,000 to 1,400 years later. Therefore, the vegetation communities and soils on Fort Richardson would be about 1,000 years younger than the Kenai development. Boreal forests on Fort Richardson would have been expected to have evolved some 7,600 to 8,000 years ago.

Soil development on Fort Richardson from weathering of glacial deposits and the vegetative succession described above would be expected to be very slow. The present day description of soils bear out this expectation. The modern soils are immature and shallow. The thin A and B horizons are often irregular or broken. Coarse gravels and larger rock fragments from glacial till are omnipresent in all soil horizons.

The lowland area on Fort Richardson supports coniferous or mixed coniferous-hardwood forests. These forest soils are acidic and the lower part of the A horizon usually has a thin and often discontinuous layer of grayish-white or ash colored material. The ash-colored layer is the result of highly leached A horizon and is typical of coniferous forest. These soils are typically called Podzols.

Fort Richardson's soils are shallow, immature and deficient in the primary plant nutrients, especially nitrogen and phosphorous. In addition, they often exhibit low water retention capability, making them a primary limiting factor for vegetative growth during dry periods. In depressions and saturated areas, such as wetlands, surface horizons may be covered with partially decomposed herbaceous vegetation called peat. Fort Richardson soils are shown in Figure 2-5.

2.2.3.2 Soil Survey

This section contains descriptions of major soil series occurring on Fort Richardson. These are taken from the Soil Conservation Service (SCS, now known as the NRCS) study (SCS 1979).

Homestead series: Homestead silt loam is the most common type of soil on the post. It is a shallow, well-drained soil formed in loess over very gravelly drift on moraines and outwash plains. Terrain varies from level, to rolling, to strongly sloping. Permeability is moderate to moderately rapid. Runoff ranges from slow to very rapid, and the erosion hazard is slight to severe.

Purches series: This moderately well-drained to somewhat poorly-drained silt loam is found on muskeg borders and slight depressions in glacial moraines. It has a surface layer of black silt loam and a subsurface layer of gray silt loam. The subsoil is mottled dark brown and the substratum grayish brown. It was formed in glacial till. Terrain is smooth to moderately sloping. Permeability is moderate to moderately slow in the more compact till. Available water capacity is low, and erosion hazard is low to moderate.

Kasilof series: This excessively drained silt loam is found on outwash plains and stream terraces. It was formed in a thin mantle of loess over very gravelly alluvium. The surface layer is dark gray silt loam. Subsoil is dark brown gravelly loam, and the substratum, dark olive gray, very gravelly sand. Runoff is slow to rapid, and erosion hazard is slight to severe. This soil series is a potentially severe threat for flash flooding.

Jacobsen series: This very stony silt loam is poorly drained and found in small valleys, shallow depressions, and low-lying areas bordering muskegs. It was formed in very stony glacial till. A typical soil profile has a peaty surface mat covering a black, very stony silt loam layer. Stones and cobbles make up about 40 percent of the volume, and gravel makes up about 20 percent. The water table is normally less than two feet below the surface. Permeability is moderate, and erosion hazard slight.

Doroshin series: This soil series is comprised of peat over a substratum of dark greenish gray silt loam. It is poorly drained and found in muskeg borders and depressions in glacial moraines. Permeability is moderate. Runoff is very slow to moderate, and erosion hazard slight.

Salmatof series: This soil is comprised of dark reddish brown coarse peat materials. It is very poorly drained and occurs in broad basins and depressions. The water table is usually near the surface.

Tuomi series: This silt loam soil is well drained and occurs on low moraines. The soil consists of silt loam over sandy loam and has moderate permeability. Runoff is slow to medium, and hazard of erosion slight to moderate.

Slikok series: This soil is a mucky silt loam occurring in valley bottoms and low areas around lakes or muskegs. The soil has a peaty surface layer. Terrain is nearly level. The soil has a high water capacity and a moderate permeability. Surface runoff and erosion hazard are moderate.

Caswell series: This series consists of coarse silt loam formed in silty and sandy waterlaid sediments over gravelly sand. It occurs on low terraces and in broad depressions. Water capacity is moderate, and permeability moderate to rapid. Surface runoff is slow, and erosion hazard is slight. The water table is normally two to four feet below the surface.

Clam Gulch series: This series consists of deep, poorly-drained silt loam that occurs in floodplains and in depressions in glacial moraines. It has dark silt over gray sediments that are high in clay. Water capacity is high, and the water table is often near the surface. Surface runoff is slow to rapid, and erosion hazard is slight to severe.

Chena series: This series consists of sandy-skeletal silt loam that is excessively drained. It occurs in alluvial fans and floodplains. The substratum contains 35 to 50 percent gravel and up to 10 percent cobbles. Permeability is moderate to rapid, and water capacity is low. Surface runoff is slow, and erosion hazard is slight.

Niklason series: This series is characterized by coarse silt loam occurring on floodplains and broad low-lying stream terraces. Soil is dark grayish brown silt loam and fine sand over gravelly sand. Water capacity is moderate to low, and permeability is moderate to rapid. Surface runoff is slow, and erosion hazard slight. This soil is susceptible to flooding but is a good source of sand and gravel.

2.2.4 Water Resources

2.2.4.1 Surface Water

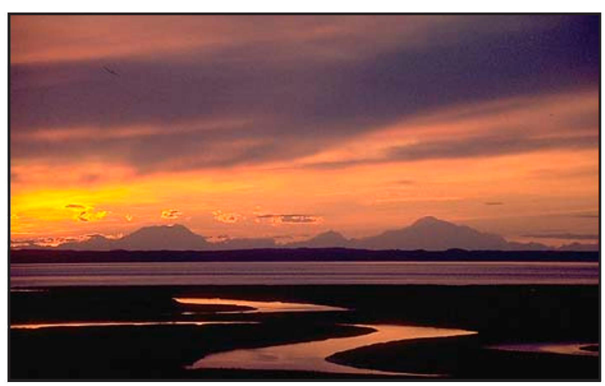
Fort Richardson's surface water resources are diverse and include numerous streams, lakes, ponds, and a saltwater tidal bay. Figure 2-6 indicates the location of surface water resources on the post.

The quality of surface water on Fort Richardson appears to have remained good throughout the Army's occupation of the area. There is no reason to suspect that these waters have either degraded (beyond localized, temporary sedimentation) or improved.

Water samples were collected from the Eagle River at three locations on two occasions. Sampling locations were Chugach State Park Campground, Bailey Bridge, and the take-out point above the Route Bravo Bridge (Horne Engineering Services Inc. 1996). The first sampling effort occurred on May 26, 1995, and the second in August, 1995. Since problems have not been found, there has been only limited monitoring of surface waters at other locations.

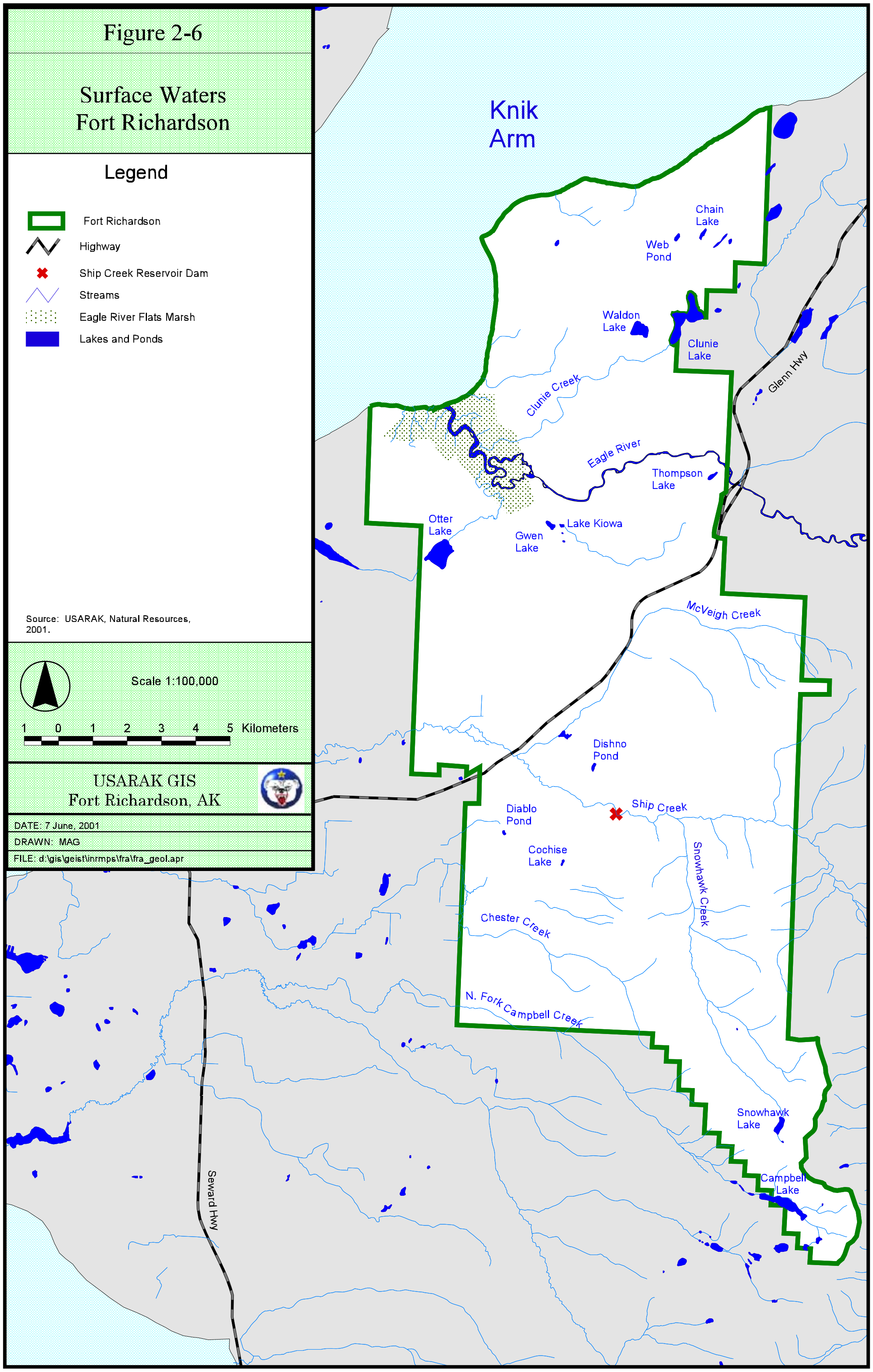
2.2.4.1.1 Streams

Most streams on Fort Richardson flow from headwaters in the Chugach Mountains to the Cook Inlet (saltwater), and traverse the post in a westerly direction. Eagle River is fed by a glacier. Flow volume of streams fluctuates dramatically from season to season. During the long period of freeze, usually from October to April, flow is limited to groundwater seepage from aquifers into streams. Snowmelt typically begins in April and reaches its peak in June; stream flow is greatest during the months of June and July. After July most of the snow has melted, but the stream flow during the months of August and September remains steady because it is augmented by rainfall (Gossweiler 1984).



Eagle River flows into Knik Arm with Mt. McKinley and the Alaska Range as a backdrop.

Figure 2-6. Fort Richardson Surface Waters.



Eagle River is the largest source of surface water on the post. It flows at an average rate of 519 cubic feet per second and drains approximately a 192-square-mile watershed, characterized by both mountains and lowlands (CH2M Hill 1994b). The Eagle Glacier comprises 13 percent of the watershed, and snow and ice melting from the glacier is a major source of flow during the summer months (Gossweiler 1984). River flow reaches its peak of more than 2,500 cubic feet per second during July and August. Periods of heavy rainfall or rapid melting from the glacier can generate water flow in excess of 3,600 cubic feet per second (CH2M Hill 1994b).

Upstream of Fort Richardson, the Eagle River passes through the community of Eagle River. From there the river flows into the northwestern portion of the post and through the ERF tidal marsh before it empties into the Knik Arm of Cook Inlet (CH2M Hill 1994b). In winter, the Eagle River is a clear stream with excellent water quality. During spring-summer, however, there are significant levels of suspended sediment from runoff and glacial melt (Gossweiler 1984). Overall sediment loads are fairly low in comparison with other glacially fed streams in Alaska (CH2M Hill 1994b).

Besides the water that comes via the Eagle River, ERF is also fed by two small tributary streams, Otter Creek and Clunie Creek. Otter Creek is a perennial stream, which drains Otter Lake just north of the cantonment area, and then flows north into ERF. Clunie Creek, an intermittent stream, drains Clunie Lake and other small ponds among the moraines on the northeast portion of the post as it flows west into ERF (CH2M Hill 1994b).

On Fort Richardson, Ship Creek is second only to Eagle River in volume. It drains a watershed of 117 square miles, 90 of which are in the Chugach Mountains. From the mountains, the creek flows west across a coastal plateau through Fort Richardson, Elmendorf AFB, and an industrial area of Anchorage before meeting Cook Inlet at the mouth of Knik Arm. Although there are no tributaries in these lowlands, the Anchorage area comprises 27 square miles of the creek's watershed.

Ship Creek traverses Fort Richardson from east to west for approximately eight miles. Entering the post, it initially flows through a three mile canyon of white water beginning at an elevation of 1,100 feet above sea level. Emerging from the canyon at an elevation of approximately 500 feet, it continues across the forested coastal plain to the western boundary of the post at an elevation of 230 feet. Ship Creek and its floodplain above the Glenn Highway is the least disturbed portion of the creek on Fort Richardson.

Upper Ship Creek flows through a pristine mountain valley.

The Fort Richardson Dam on Ship Creek forms a sizable reservoir, which provides all the potable water for Fort Richardson and the Elmendorf AFB and nearly half the water for the Municipality of Anchorage. Fort Richardson and Anchorage have separate water treatment plants and delivery systems. Fort Richardson also has several backup water wells fed by a shallow aquifer along Ship Creek south of the post's Central Heat and Power Plant. Additional information regarding Ship Creek and Ship Creek Dam can be found in *Chronology of Water Use and Water Rights on Ship Creek* (Quirk 1997).

Snowhawk Creek is a perennial tributary of Ship Creek flowing from its mountainous drainage basin. It drains a small cirque lake in the Chugach Mountains on the southern portion of the post and flows north through Snowhawk Valley into Ship Creek about six miles further downstream (Gossweiler 1984).

Chester Creek and the North Fork of Campbell Creek are the only other perennial streams on the post. Chester Creek drains a small basin located on the southern portion of Fort Richardson on the western slope of the Chugach Mountains. It flows